

Reptiles as Long-lived Receptors for Ecological Risk Assessment in Aquatic Ecosystems of the Southeastern U.S.

Andrew M. Grosse, Robert V. Horan III, David E. Scott, Bess B. Harris, Tracye M. Murphy, Brian S. Metts & Tracey D. Tuberville
Savannah River Ecology Lab, University of Georgia, Aiken, SC 29802

Introduction

Future management and remediation recommendations for contaminated aquatic ecosystems will depend in part on predicted risks to wildlife species from contaminant exposure and accumulation. The Savannah River Site (SRS), near Aiken, South Carolina, USA, is a 800-km² Department of Energy installation at which some localized areas contain elevated concentrations of radioactive and metal contaminants. Ecological risk assessment models have been developed for river otters and belted kingfishers to examine the potential effects of metal contaminants on wildlife associated with aquatic systems on the SRS. However, models for these relatively short-lived species (otters, 8-9 yrs; kingfisher, 15 yrs) may not adequately estimate the exposure risks for species at similar trophic levels but with much longer life spans. American alligators and several turtles species occur in aquatic systems of the SRS, have diets composed largely of vertebrate and/or invertebrates, and have estimated longevity of up to 40-70 years. By virtue of their long life spans, physiology, and trophic status as top predators, alligators and turtles may accumulate significant body burdens of a variety of contaminants. Thus these species may be good ecological receptors for assessing risks associated with long-term contaminant exposure.

Methods

Sampling began in April 2010 and we sampled turtles—primarily yellow-bellied sliders (*Trachemys scripta*)—and alligators (*Alligator mississippiensis*) from a series of aquatic sampling sites that differed in their contaminant types, levels and spatial scales, including references sites not known to be contaminated. We permanently and uniquely marked all animals, took standard morphometric measurements, and measured gamma radiation. In addition, we collected whole blood, nail, and scute (alligators only) samples for metals analysis.

Yellow-bellied Slider (*Trachemys scripta*)

- Estimated longevity = 30+ years in the wild
- Longevity record = 46 yrs (Wild); 49 yrs (Captive)
- Generalist species throughout their range
- Common in all aquatic habitats on the SRS
- Cs-137 accumulates in tissue
- Previous body burden and mark-recapture data on SRS



Capture Techniques

Turtles were caught primarily with baited hoop traps but also dipnets and by hand. Hoop traps were set at each location for 4 days/3 nights, except those sites with large alligators. At these locations hoop traps were set each morning and collected each night.

American Alligator (*Alligator mississippiensis*)

- Estimated longevity = 40-50 years
- Longevity record = unknown (wild); 73 yrs (captive)
- Top carnivores in aquatic ecosystems
- Found in most aquatic habitats on SRS
- Hunted elsewhere in range
- Cs-137 accumulates in tissue
- Previous body burden and mark-recapture data on SRS

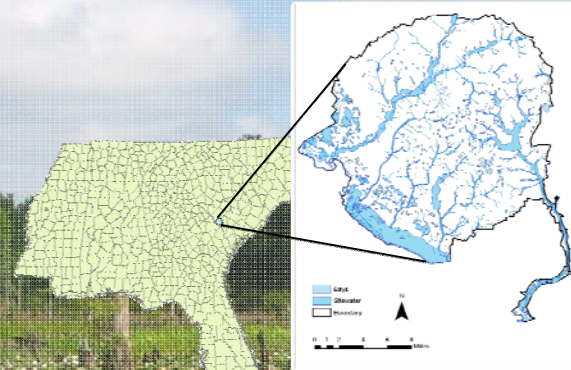


Capture Techniques

Alligators were captured using Murphy traps and by hand. Murphy traps were set at each location for 4 days/3 nights and night time sampling was conducted once each week.

Data Collection

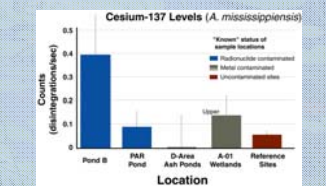
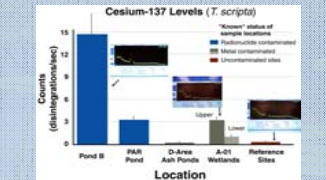
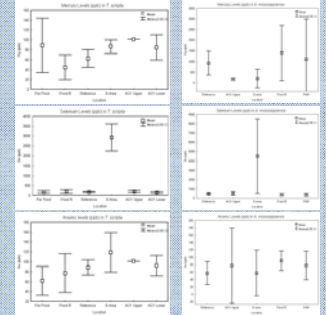
We used a Canberra multi-channel analyzer and Genie 2000 spectroscopy system with a 10.16 x 15.24 cm NaI crystal to determine ¹³⁷Cs total body burden in subsamples of turtles and young alligators from each location. Large alligators (> 40 cm) were counted with Eberline ESP 2 Gamma Counter. The region of interest for ¹³⁷Cs was 596-728 keV. Count times were generally 30 minutes. The counting data was corrected for background radiation, the physical decay of ¹³⁷Cs phantoms used to estimate counting efficiency, and the contribution of other radioisotopes to the ¹³⁷Cs region. In addition, whole blood was analyzed for a suite of metals.



The Savannah River Site

- Located in South Carolina, SE of Augusta, GA
- Created in 1950 for nuclear materials production
- Covers an area of ~78,000-ha
- Aquatic habitats consist of four large impoundments as well as several small, abandoned farm and mill ponds and over 400 isolated wetlands.
- Ecological research and environmental characterization conducted since the 1950's
- Has very high reptile and amphibian diversity (103 species recorded)
- One of seven DOE National Environmental Research Parks, where researchers are able to study the environmental impacts of energy development

Preliminary Results



Metal Contaminated Sites

D-Area Ash Basin

- Coal-fired steam production facility that generates coal fly ash waste
- Fly ash deposited into open settling basins ~500 m from the Savannah River
- Contains trace elements including arsenic, chromium, cadmium, and selenium
- Metals found at high levels in aquatic and semi-aquatic biota
- Some above EPA limits for humans
- Contaminated taxa include reptiles, amphibians, mammals, fish, invertebrates, and birds based on previous sampling



AO1 Wetland Complex

- A complex of retention ponds with eight artificial wetlands designed to remove metals (primarily copper and lead) from industrial effluent
- The Upper Pond (0.62-ha retention basin) receives facilities' effluent
- The Lower Pond (0.52-ha impoundment) receives remediated wetland effluent

Radioactive Sites

PAR Pond and Pond B

- PAR Pond, a 1100-ha reservoir constructed in 1958; used for cooling the P and R nuclear reactors
- Pond B, a 81-ha reservoir constructed in 1961; used for cooling the R nuclear reactor
- PAR Pond received thermal effluent from 1958 – 1988; Pond B from 1961 – 1964
- Cooling water discharged to both reservoirs contained ¹³⁷Cs, ⁹⁰Sr and other radionuclides; PAR Pond declared a CERCLA site
- Today ¹³⁷Cs is still present in sediment, aquatic macrophytes, and biota
- Ponds have elevated levels of mercury due to history of using Savannah River as source of cooling water



Discussion

- Monitoring accumulation of ¹³⁷Cs and trace metals in wildlife is important in determining potential risks of long-term contaminant exposure
- Additionally, results may lead to more stringent requirements and regulations pertaining to the human consumption of alligators and turtles
- The Environmental Protection Agency (EPA) max contaminant level goals (MCLG) for human consumption are 2 ppb (Hg), 10 ppb (As), and 50 ppb (Se).
- Our data, when combined with long-term mark-recapture and previously collected body burden data, offer the opportunity to study legacy effects of contaminants in aquatic systems
- Although some metal and radionuclide analyses documented elevated levels, most captured animals appear to be physically healthy.
- Future work will include measuring other biological endpoints, including reproductive success, hatching fitness, & molecular and cellular level damage

Acknowledgements

We would like to thank Judy Greene for assistance with turtle processing and the numerous SREL technicians and interns for their field and lab assistance. Funding was provided by the Area Completions Project of Savannah River Nuclear Solutions, and work partially supported by the Department of Energy under Award Number DE-F09-07SR22506 to the University of Georgia Research Foundation.

